WHY IS IT NECESSARY TO CLEAN UP DOE SITES?

OUR NATION'S COLD WAR LEGACY

For more than 50 years the United States has used nuclear energy for both peaceful and military purposes. This use resulted in the creation of a vast network of facilities across the nation engaged in research, development, production, and testing of nuclear materials. Since most of this nuclear material has been related to weapons, this network is referred to as the nuclear weapons complex. The U.S. Department of Energy (DOE) and its predecessor agencies (the Atomic Energy Commission and the Energy Research and Development Agency) have primary responsibility for the nuclear weapons complex. A civilian agency has always been responsible for this nuclear weapons network.

With the end of the cold war threat in the early '90s and the subsequent shutdown of all nuclear weapons production reactors in the United States, DOE has shifted its emphasis to remediation, decommissioning, and decontamination of the immense volumes of contaminated water, sediments, and the over 7,000 structures spread over 7,280 square kilometers. The Department must characterize, treat, and dispose of hazardous and radioactive waste at more than 120 sites in 36 states and territories. This includes 475 billion gallons of contaminated groundwater in 5,700 distinct plumes, 75 million cubic meters of contaminated sediments, and 3 million cubic meters of leaking waste buried in landfills, trenches, and spill areas (*Linking Legacies Report*, January 1997). The first few years of this activity, up to 1995, have mainly involved cataloging and preliminary characterization. This alone has cost the Department more than $23 billion. Budget projections for these activities just for the next 10 years exceed $60 billion. The DOE cleanup of the Cold War Legacy is the largest program of its kind ever undertaken by the United States.

OVERALL ENVIRONMENTAL RESTORATION

DOE's Office of Environmental Management (EM) has the major responsibility for this enormous clean-up effort. EM has four major objectives for its science and technology investments (*EM Research and Development Program Plan*, October 1998): (1) meet high-priority needs; (2) reduce the cost of EM's major cost centers (areas where DOE has its major cleanup investments); (3) reduce EM's technological risk; and (4) accelerate technology deployment. To meet these objectives, EM has sought the assistance of the basic research programs in DOE's Office of Biological and Environmental Research, especially the Natural and Accelerated Bioremediation Research (NABIR) program. In addition, EM has established ten Site Technology Coordination Groups (STCGs) to coordinate technology assessments at the main hazardous waste sites in the DOE complex. (See "Bioremediation Web Sites" at the end of this primer for a link to the STCG web sites.) Each STCG maintains a dynamic list of its sites' highest priority science and technology needs for effective cleanup. This list is updated annually. From this list, EM has identified five major environmental restoration needs (*EM Research and Development Program Plan*, October 1998):

(1) The most cost-effective remediation plans require a complete and accurate understanding of the inventory, distribution, and movement of contaminants in the vadose and saturated zones. Improved analytical tools, in situ monitoring devices, understanding of permeability patterns, and tools to predict groundwater flow and transport are required to characterize and quantify these contaminants.

(2) The ability to contain or stabilize leaks and buried waste hot spots in situ requires resolution of problems in several areas. Improved surface barrier systems are needed to provide effective containment of leaking landfills, trenches, tanks, and high-concentration plumes. Methods are needed to stabilize buried wastes in situ to prevent leaching and contaminating of the vadose zone. Cover systems that provide robust waste isolation over a range of climatic conditions and extreme events for periods of over 100 years are necessary for many applications. Finally, in situ treatment barriers need to be developed to provide effective remediation of dispersed contaminant plumes.

(3) The ability to treat or destroy mobile contaminants in situ is dependent on resolution of problems in several areas. Bioreactive treatment methods are needed for remediation of low to moderate concentrations of organic solvents in sediments and groundwater. Chemical treatment technologies to destroy or immobilize highly concentrated contaminant source terms (metals, radionuclides, explosive residues, and solvents) in the vadose and saturated zones are required to increase remediation rates. Finally, improved deep drilling technology is needed to provide access to deep contaminant plumes for sampling, retrieval, and delivery activities.

(4) Highly radioactive, explosive, and pyrophoric wastes pose unacceptable risks to remediation workers during retrieval and treatment. The capability for on-site characterization and remote retrieval of these hot spots that are not amenable to in situ treatment must be developed.

(5) In order to obtain regulator and stakeholder acceptance of contaminant, stabilization, and treatment technologies in remediation plans, methods to validate and verify containment and treatment system performance and integrity must be developed.

The Focus on Radionuclides and Metals

The NABIR program addresses a large number of DOE's environmental restoration needs by conducting basic research on natural and accelerated bioremediation, especially as it relates to radionuclides and metals in subsurface environments. The research being funded by the program specifically focuses on one or more components in each of the above five need areas. The necessity for basic research to focus on radionuclides and metals is further illustrated by a review of DOE contaminants by waste site and facility (Riley et al., 1992). This review of DOE chemical contaminants and mixtures for the Subsurface Science Program is one of the few comprehensive comparisons of DOE contaminants ever done. This report shows that more than 50% of the facilities and 35% of the waste sites have radionuclide and metal contamination. In soils and sediments, radionuclides and metals are the highest frequency classes of contamination by waste site and the 3rd and 4th highest frequency classes by facility (Figure 1.1). However, the first two classes by facility (fuel and chlorinated hydrocarbons) are technologically further advanced in the development of cost-effective and efficient solutions. Therefore, remediation of radionuclides and metals currently requires greater research emphasis to support technology development.

Contaminants in groundwater at DOE facilities are also dominated by metals and radionuclides, with more than 60% having these types of waste (Figure 1.2). Metals and radionuclides also are the highest frequency compound class by waste site, with more than 50% having these contaminants. The only contaminant that exceeds the frequency of metal and radionuclide contamination in groundwater is chlorinated hydrocarbons, for which there are already a large number of potential solutions.

The need for basic research to focus on metals and radionuclides is further underscored by the recognition that radionuclides are a uniquely DOE problem. Because nuclear production was carried out by the DOE at DOE sites, it has not received the research attention or funding by other government agencies that solvents, fuels, and a few of the metal contaminants have received. A thorough understanding of subsurface mobilization and immobilization of radionuclides and metals will allow us to manipulate, stabilize, and predict long-term stability of these contaminants and their relative risk. This research will not only facilitate our overall understanding of our environment, but also potentially save DOE millions if not billions of dollars in life cycle costs of cleanup of the Cold War Legacy.

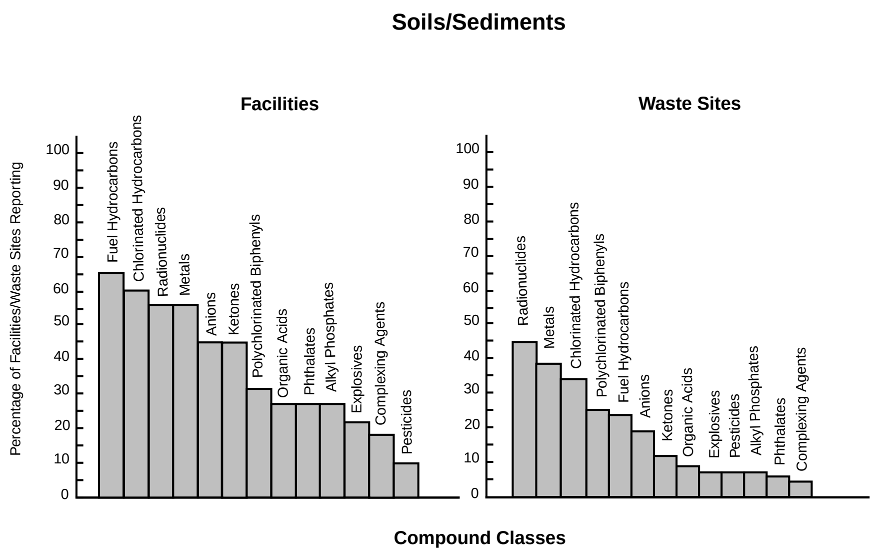

Figure 1.1. Distribution of compound classes in soils/sediments at 18 DOE facilities and 91 waste sites (Riley et al., 1992).

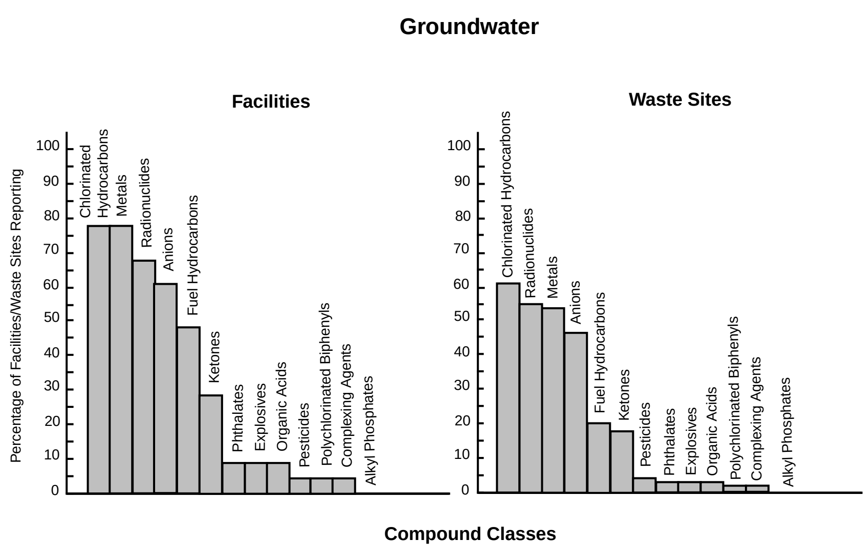

Figure 1.2. Distribution of compound classes in groundwater at 18 DOE facilities and 91 waste sites (Riley et al., 1992).